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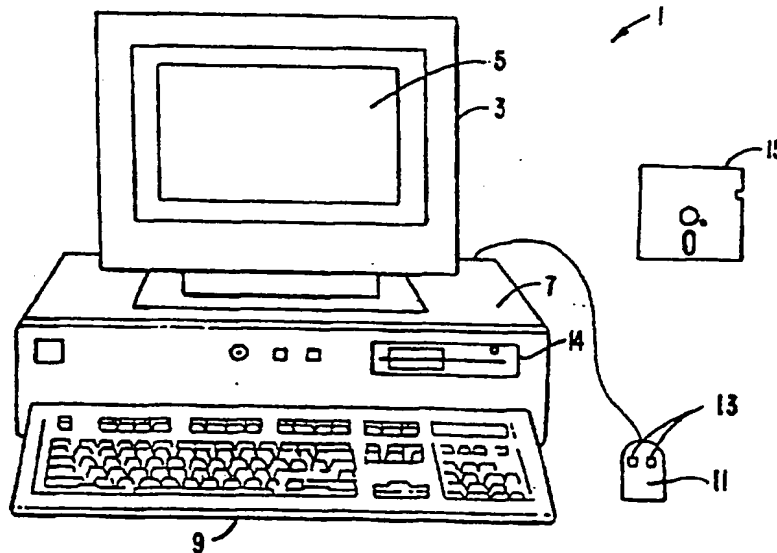
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(54) Title: FLICKER REDUCTION SYSTEM FOR COMPUTER GRAPHICAL INTERLACED DISPLAY

(57) Abstract

A flicker reduction system (1) for display of computer graphics on an interlaced display is provided. Under the control of a computer or game system, horizontal lines are analyzed to determine if flicker conditions are present. If flicker conditions exist, a horizontal line may be constrained to occupy a certain field depending on the location of the graphical object relative to other graphical objects. Analyzing flicker conditions allows a flicker-free display to be created without unnecessarily reducing resolution of the display. The flicker conditions may be analyzed whenever a new graphical object is created or when an existing graphical object is moved. Additionally, all horizontal edges may be constrained to being displayed in the same field to reduce flicker.

FLICKER REDUCTION SYSTEM FOR
COMPUTER GRAPHICAL INTERLACED DISPLAY

BACKGROUND OF THE INVENTION

The present invention is related to computer graphical display systems and, more particularly, to computer generated graphics that have reduced flicker when displayed on an interlaced display.

5   Ages ago, people discovered that if multiple still pictures are sequentially flashed to a person, the person saw what appeared to be continuous motion. At a rate of around 50 to 60 frames a second, a person is not able to discern the individual frames and thus perceives continuous motion. Below

10   this rate, the person is able to discern the individual frames which results in "flicker."

Picture flicker is caused by the latency and the lateral inhibition mechanism of the visual neural system. Conventional computer monitors update the frames or the full

15   screen images at a rate fast enough so that a person does not perceive flicker. Computer displays typically are noninterlaced raster scan with a refresh rate of 60-70 frames per second.

There are many instances where the computer generated

20   graphics are displayed on an interlaced display. One reason is that interlaced display monitors are less expensive than noninterlaced display monitors. Additionally, it is now common to use televisions (which are interlaced) for games, presentation graphics, multimedia, program menu selection, and

25   the like. The television standard (NTSC) specifies 30 frames per second where each frame is composed of two interlaced fields with each field being half of the full frame image.

Flicker is generally not a problem on television even though the frame rate is below the flicker threshold because

30   with normal television pictures, the information in one field (e.g., the odd field) has a high level of correlation with the

information in the other field (e.g., the even field).
However, when a television is used as a display device for
computer generated graphics, the images in the two fields
usually do not have the high level of correlation which can
5   result in flicker. This is especially true where two
horizontal edges which are close to each other reside in
different fields.

Past attempts to reduce flicker of computer generated
images on televisions or other interlaced display devices have
10   attempted to do so by removing the interlace effect and
displaying the odd field in the same position as the even
field. However, this approach has the disadvantage of reducing
the vertical resolution in half.

The book "Video Demystified" by Keith Jack (HighText,
15   1993) describes a method where each pixel on the horizontal
scan line are a weighted average of the contiguous pixels above
and below the scan line in a frame. The weighted average is
then output to an interlaced display device. This approach is
implemented in Cirrus Logic's GD5425-TV chip. The averaging of
20   horizontal lines removes the high contrast vertical transitions
but it also smoothes out the picture. Thus, flicker reduction
comes at the price of reduced resolution and flicker is still
noticeable in high contrast areas.

As the use of interlaced display devices with
25   computer graphics becomes more and more prevalent, systems and
methods are needed that reduce or eliminate flicker while not
unnecessarily compromising the display resolution. The present
invention fulfills this and other needs.

30   **SUMMARY OF THE INVENTION**

The present invention provides systems and methods of
reducing or eliminating flicker in an interlaced display device
without unnecessarily reducing the display resolution. The
present invention provides rules that identify conditions that
35   will cause flicker on an interlaced display device. After a
flicker condition is identified, the system or the user
modifies the graphical image to avoid the flicker. Since

conditions that cause flicker are detected, a truly flicker-free display may be achieved.

In accordance with the present invention, a rule based system is provided for generating flicker-free interlaced display of computer graphics. The system may be interfaced on several levels. Graphic drawing packages may utilize the invention as a design rule check which prevents the creation of objects which will cause flicker or to flag flicker conditions so the user can remove the conditions if desired. At another level with an interactive user (e.g., a windows application or game program), the system may move windows or objects, such as icons or sprites, so that flicker conditions do not occur. For example, an application program or an operating system may incorporate the present invention to restrict how windows and objects are drawn or moved on the display.

A typical system implementing the present invention includes a computer (or game machine), video display hardware which displays the image stored in a video frame buffer (or hardware like sprite hardware) in two interlaced fields, and an interlaced display device for displaying the two fields. The computer or video display hardware may store a set of formal rules specifying conditions that will produce flicker. Whenever an object is created or moved, these rules are referenced and checked. The computer may also store and display objects or images which have been created on another system utilizing the invention.

The formal rules specify conditions which will cause flicker in an interlaced display device. An important condition is that two horizontal edges (e.g., edges of a graphical object) in different fields are in close proximity. Other conditions may include the horizontal overlap of two horizontal edges, the vertical distance between two horizontal edges, and the luminous intensity difference between two horizontal edges and the intervening background.

In one embodiment, if all the conditions indicate that flicker will be produced by two horizontal edges, an object will be moved or resized so that the two horizontal edges will be in the same field. Additionally, a flicker flag

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may be set so that the application program or user can address the identified flicker condition.

In some embodiments, only a subset of the flicker conditions will be tested. If only a subset of the flicker conditions are tested, the untested conditions are assumed to indicate a flicker condition. In this manner, if all the conditions, both tested and untested, indicate flicker will be produced, the system or user address the identified flicker condition.

In another embodiment, objects (e.g., windows) are created and moved so that all outer horizontal edges of the object that are darker than the background are constrained to be in the same field as the outer horizontal edges of other objects that are darker than the background. Thus, flicker is reduced because all the outer horizontal edges of objects that are darker than the background will be in the same field. Additionally, outer horizontal edges that are lighter than the background may be constrained to the other field.

Other features and advantages of the present invention will become apparent upon a perusal of the remaining portions of the specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an example of a computer system used to execute the software of the present invention;

Fig. 2 shows a system block diagram of a typical computer system used to execute the software of the present invention;

Fig. 3A shows a block diagram of an external scan converter configuration and Fig. 3B shows a block diagram of an internal scan converter configuration;

Fig. 4 is a screen including two graphical windows to illustrate flicker conditions;

Fig. 5 is a screen including two graphical windows having multiple borders;

Fig. 6 is a screen including three graphical objects;

Fig. 7 shows a flowchart of one embodiment of the present invention that determines if a graphical object will cause flicker;

Fig. 8 shows a flowchart of analyzing flicker conditions of horizontal edges for use with Fig. 7;

Fig. 9 shows a flowchart of another embodiment of the present invention that reduces flicker caused by graphical objects; and

Fig. 10 is a screen including a window with two borders.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Definitions: The following are definitions of some of the terms used herein.

Scan line - produced by the electron beam as it passes from one side of the raster to the other between horizontal retraces.

Field - set of alternating scan lines in an interlaced display device (e.g., odd or even field).

Horizontal line - resides on one scan line and has a single luminous intensity.

Horizontal strip - object composed of adjacent horizontal lines of the same luminous intensity.

Horizontal edge (or edge) - horizontal line which has at least one adjacent horizontal line of different luminous intensity.

Outer horizontal edge - horizontal edge of an object which defines the top or bottom boundary of the object.

In the description that follows, the present invention will be described in reference to an IBM personal computer system in an MS-DOS or Microsoft Windows environment. The present invention, however, is not limited to any particular environment or any particular application. Instead, those skilled in the art will find that the systems and methods of the present invention may be advantageously applied to a variety of systems, including different platforms of computers, games systems, presentation systems, and graphical overlay systems which combine graphics over video. Therefore, the

description the embodiments that follow is for purposes of
illustration and not limitation.

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Fig. 1 illustrates an example of a computer system
used to execute the software of the present invention. Fig. 1
shows a computer system 1 which includes a monitor 3, screen 5,
cabinet 7, keyboard 9, and mouse 11. Mouse 11 may have one or
more buttons such as mouse buttons 13. Cabinet 7 houses a
floppy disk drive 14 or a hard drive (not shown) which may be
utilized to store and retrieve software programs including
computer code incorporating the present invention, graphical
images created utilizing the present invention, and the like.
Although a floppy disk 15 is shown as a computer readable
storage medium, other computer readable storage media including
hard disks, CD-ROM, flash memory, RAM, ROM, and tape may be
utilized. Cabinet 7 also houses familiar computer components
(not shown) such as a processor, memory, and the like.

Fig. 2 shows a system block diagram of computer
system 1 used to execute the software of the present invention.
As in Fig. 1, computer system 1 includes monitor 3 and keyboard
9. Computer system 1 further includes subsystems such as a
central processor 102, system memory 104, I/O controller 106,
display adapter 108, serial port 112, disk 116, network
interface 118, and speaker 120. Other computer systems
suitable for use with the present invention may include
additional or fewer subsystems. For example, another computer
system could include more than one processor 102 (i.e., a
multi-processor system) or a system may be controlled by a
microcomputer.

Arrows such as 122 represent the system bus
architecture of computer system 1. However, these arrows are
illustrative of any interconnection scheme serving to link the
subsystems. For example, speaker 120 could be connected to the
other subsystems through a port or have an internal direct
connection to central processor 102. Computer system 1 shown
in Fig. 2 is but an example of a computer system suitable for
user with the present invention. Other configurations of
subsystems suitable for use with the present invention will be
readily apparent to one of ordinary skill in the art.

Fig. 3A and 3B show block diagrams of different computer display hardware that may be used with the present invention. Fig. 3A shows a block diagram of an external scan converter configuration. Display adapter 108 includes a frame

5   buffer 150 and a VGA chip 152. The frame buffer is a block of dedicated memory that stores the screen image displayed on the monitor. A "frame" will be used herein to describe a full screen image. The VGA chip reads data stored the frame buffer and produces a computer monitor signal 154 that produces the

10   screen image on a VGA monitor 156.

In a noninterlaced monitor, a frame is produced on the screen when the scanning electron beam in the monitor sweeps once from top to bottom (i.e., between vertical retraces). However, in an interlaced monitor, only half the

15   frame is produced when the scanning electron beam in the monitor sweeps from top to bottom because only one field is displayed. Therefore, a frame in an interlaced monitor is composed of two fields which are offset from each other vertically by half a scan line. The fields are commonly

20   referred to as the odd and even fields, respectively.

Still referring to Fig. 3A, in a typical computer, display adapter 108 outputs the contents of the frame buffer at a rate compatible with VGA monitor 156. The frame buffer is output in computer monitor signal 154 comprising frames of full

25   screen images. Thus, the computer monitor signal is, in effect, a noninterlaced signal. As an example, a Video Graphics Array (VGA) display adapter may output the frames at a rate of 60 Hertz. However, computer monitor signals are generally incompatible with the standard television signal

30   (NTSC). Therefore, an external scan converter 158 converts the computer monitor signal to a television signal 160.

The external scan converter includes a scan converter 162 that produces an interlaced signal which is input to an NTSC encoder 164. The NTSC encoder produces the television

35   signal that is displayed by a television 166. Television signals are composed of 30 frames a second but since the frames are interlaced, the television has a refresh rate of 60 fields per second.

Fig. 3B shows a block diagram of an internal scan converter configuration. Some display adapters incorporate circuitry that produce television signals. As shown, display adapter 108 includes frame buffer 150, a VGA interlaced chip 170, and NTSC encoder 164. An example of the VGA interlaced chip is Cirrus Logic's GD5425-TV chip. The VGA interlaced chip reads data stored the frame buffer and produces an interlaced signal. The NTSC encoder takes the interlaced signal and produces the television signal that is displayed by television 166. Thus, an internal scan converter provides functionality similar to the external scan converter except that the electronics are located on the display adapter.

In general, the present invention reduces flicker by recognizing the conditions that will cause flicker. In one embodiment, graphical objects are constrained to positions on the screen that will not produce flicker. In another embodiment, graphical objects are analyzed when they are created or moved to determine if flicker will result. Flicker may result if two horizontal edges are in different fields. Thus, a flicker condition is that two horizontal are in different fields. A horizontal edge of a graphical object may be internal or near the periphery (an "outer horizontal edge"). Although the simplest horizontal lines and edges may be a single color, horizontal lines and edges may be dotted or otherwise composed of more than one color. Other flicker conditions include the horizontal overlap of the horizontal edges, the vertical distance between the horizontal edges, and the luminous intensity difference between two horizontal edges and the intervening background.

If all of the flicker conditions indicate (e.g., by crossing a threshold value) flicker will occur, one of the horizontal edges may be displayed in a different field (i.e., same field as the other horizontal edges) to avoid the flicker. This eliminates the flicker while not unnecessarily lowering the resolution.

In general, the thresholds for the flicker conditions are mutually dependent and may be determined by psychometric measurement. The thresholds for the flicker conditions may be

stated as dependent functions, stored in a table or set as
constants. Different applications of the present invention may
utilize different threshold values. Additionally, not all the
flicker conditions need be tested. For example, if an
5   application displays black bordered windows on a white
background, it may not be necessary to test the chroma-
luminance intensity flicker condition.

        For illustration purposes, the present invention will
now be described as being implemented in a computer system that
10   displays graphical windows on an interlaced screen. As a
graphical window is created or moved, the system checks to see
if the graphical window will produce flicker. If the system
determines the graphical window will produce flicker, the
system will move or resize the graphical window such that
15   flicker will not be produced. Although the present invention
will be described as being applied to the outer horizontal
edges of each graphical window as it is created or moved, it
may also be utilized to reduce flicker by analyzing the
internal horizontal edges of graphical objects, images, windows
20   or whole screens.

        Fig. 4 is a screen including two simple graphical
windows to illustrate flicker conditions. Screen 5 is an
interlaced screen composed of two fields denoted f_1 and f_2.
The screen includes graphical windows 202 and 204. When
25   graphical windows or objects are analyzed, the horizontal edges
nearest another graphical window or object are compared. Thus,
graphical window 202 includes a horizontal edge 206 that is
nearest graphical window 204. Similarly, graphical window 204
includes a horizontal edge 208 that is nearest graphical window
30   202. These two edges are analyzed to determine if the edges
will meet conditions indicative of flicker.

        Flicker will not be caused by two horizontal edges
that are in the same field. As horizontal edge 206 is in field
f_1 and horizontal edge 208 is in field f_2, there is a
35   possibility of flicker and one flicker condition has been
satisfied. Another flicker condition is if a horizontal
overlap 210 of the two horizontal edges is greater than a
threshold value. Yet another flicker condition is if a

vertical proximity 212 of the horizontal edges is less than a
threshold value. An additional flicker condition is if the
luminous intensity of both edges are greater than a threshold
value above (or below) the intervening background luminous
5   intensity. If all these flicker conditions are satisfied, the
edges might cause flicker.

       When the conditions indicate that the horizontal
edges will cause flicker, the system may remove the possibility
of flicker by displaying a horizontal edge in a different
10   field. Thus, flicker may be avoided by displaying both
horizontal edges in the same field. This may be accomplished
by moving or resizing an object or window. Optionally,
horizontal edges that are not longer than a certain length are
not analyzed because the flicker produced is negligible.

15   Although the present invention has been described in
terms of luminous intensity, chroma-luminance may also be
utilized. Chroma-luminance refers to both the color and
luminance of the horizontal line, edge or strip. Thus, in one
embodiment, a flicker condition is determined by subtracting
20   the intervening background chroma-luminance from the chroma-
luminance of the two horizontal edges at issue. If the signs
of these differences are the same, the magnitude (absolute
value) of the differences are compared to a threshold value.
If the magnitude of both differences are above the threshold
25   value, flicker may result. In another embodiment, flicker is
indicated if the signs of the differences are the same (i.e.,
no threshold value is utilized).

       Not all the flicker conditions need be tested. For
example, if one is creating multiple borders for windows, the
30   test may be simplified to determining if the intensity
differences between the horizontal strip and the two adjacent
backgrounds have the same sign (i.e., the bordering backgrounds
are either both lighter or darker than the horizontal strip).
Such horizontal strips may be constrained to an odd number of
35   scan lines.

       Fig. 5 is a screen including two graphical windows
having multiple borders. Screen 5 is an interlaced screen
composed of two fields denoted f_1 and f_2. The screen has a

white background and includes graphical windows 232 and 234.
Each graphical window is bordered by light gray and has an
inner border of black. Graphical window 232 has a light gray
border 236 and a black inner border 238. Similarly, graphical
window 234 has a light gray border 240 and a black inner border
242.

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The light gray borders of the graphical windows may
not produce flicker because their luminous intensity is close
to the luminous intensity of the intervening white background.
However, the inner black borders of the graphical windows may
produce flicker since they have edges that are in different
fields. Black inner border 238 has a horizontal overlap 244
with black inner border 242. The black inner borders have a
vertical proximity 246. The horizontal overlap and vertical
proximity may be compared to threshold values to determine if
flicker is indicated.

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A flicker condition is if the differences between the
luminous intensity of both edges and the intervening background
luminous intensity are the same sign and the absolute value of
the differences are both greater than a threshold value.
Although the edges of the black inner borders are separated by
the white background and the light gray border, flicker will be
indicated if both edges have a luminous intensity greater than
a threshold value above (or below) each intervening luminous
intensity. Thus, the horizontal edges in windows or objects
that produce flicker may be internal horizontal edges.

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For illustration purposes, Fig. 5 has been described
as having black borders on a white background. It should be
readily apparent that the same analysis would apply to a light
border on a dark background and a dark border on a light
background. Furthermore, the present invention is not limited
to black and white colors, these colors are chosen to simply
the reader's understanding but in a preferred embodiment the
present invention analyzes the chroma-luminance which includes
both the color and intensity of the edges.

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Graphical objects are typically more complicated than
the rectangular graphical windows shown in Figs. 4 and 5.
However, all graphical objects include horizontal edges that

may be analyzed individually. Fig. 6 is a screen including
three more complicated graphical objects. Screen 5 includes
graphical objects 300, 302 and 304. If graphical object 302
was just created or moved to its current position on the
5   screen, the system would check if the graphical object would
produce flicker. The top and bottom of graphical object 302
would be reduced to horizontal edges and the edges analyzed to
determine if the edges would interact with neighboring edges to
produce flicker.

10   Graphical object 300 includes a horizontal edge 306.
Horizontal edge 306 is compared to a horizontal edge 308 of
graphical object 308 because the horizontal edges are in
different fields and overlap. Similarly, a horizontal edge 310
is compared to a horizontal edge 312 because the horizontal
15 edges are in different fields and overlap. Additionally, a
horizontal edge 314 is compared to a horizontal edge 316
because the horizontal edges are in different fields and
overlap. Therefore, the top and bottom of graphical objects
are reduced to horizontal edges for analysis.

20   Internal and outer horizontal edges of graphical
objects may interact to produce flicker. Additionally,
horizontal edges of a graphical object may act as the top and
bottom of a horizontal strip that results in flicker. For
example, in Fig. 6 horizontal edge of graphical object 304
25 define a horizontal strip. The horizontal edges in the
background above and below this strip may interact to produce
flicker because these horizontal edges in the background are in
different fields. In other words, a horizontal strip with a
vertical height of an even number of scan lines may generate
30 flicker.

           Fig. 7 shows a flowchart of one embodiment of the
present invention that determines if a graphical object will
cause flicker. The system analyzes a graphical object (or
window) that has been created or moved on the screen to
35 determine if the graphical object will cause flicker. At step
404, the system determines if there are any horizontal edges in
the graphical object. In a preferred embodiment, the system
not only checks for horizontal edges in the graphical object

but also compares the length of the edges to a length
threshold. If a horizontal edge is not longer that the length
threshold, the edge is not processed any further. For example,
the letter "E" contains horizontal edges. However, the

5   possible flicker produced by a normal-sized font is negligible
so it may be more efficient to ignore the edges if they are
shorter than the length threshold.

If there are no horizontal edges in the graphical
object that should be processed, the graphical object will not

10   produce flicker. At step 406, a flicker flag is not set (i.e.,
off). The flicker flag is used to indicate whether the
graphical object will cause flicker when it is displayed.
Although it is shown that a flag is not set, it is not
necessary that a flag be used at all. For example, once the

15   system has determined that the graphical object will not
produce flicker, the system may just display the graphical
object.

If there are horizontal edges in the graphical
object, the system determines the horizontal edges of the

20   graphical object at step 408. Step 408 may be performed
concurrently with step 404. Once the horizontal edges of the
graphical object are determined, the system determines the
position the graphical object will be displayed on the screen
at step 410.

25   The system checks whether there are any horizontal
edges above the graphical object at step 412. If there are
horizontal edges above the graphical object (e.g., from another
graphical object), the system obtains a horizontal edge to
compare to a horizontal edge of the graphical object at step

30   414. The system then compares the edges to determine if the
edges will produce flicker. This process is described in more
detail in reference to Fig. 8. In a preferred embodiment, only
horizontal edges above the graphical object that are within the
vertical proximity threshold are identified.

35   At step 416, the system checks if there are two more
horizontal edges to compare. If there are, the system proceeds
to step 414 to get the two edges for comparison. Otherwise,
the system has checked for flicker above the graphical object.

The system then checks whether there are any
horizontal edges below the graphical object at step 418. If
there are horizontal edges below the graphical object, the
system obtains a horizontal edge to compare to a horizontal

5   edge of the graphical object at step 420. The system then
compares the edges to determine if the edges will produce
flicker which is described in more detail in reference to Fig.
8. In a preferred embodiment, only horizontal edges below the
graphical object that are within the vertical proximity

10   threshold are identified.

At step 422, the system checks if there are two more
horizontal edges to compare. If there are, the system proceeds
to step 420 to get the two edges for comparison. Otherwise,
the system has checked for flicker both above and below the

15   graphical object.

Fig. 8 shows a flowchart of analyzing flicker
conditions of horizontal edges for use with Fig. 7. At step
502, the system determines if the horizontal edges are in the
same field. One method of determining if horizontal edges are

20   in the same field is to test the least significant bits of the
binary scan line numbers of the horizontal edges (e.g., by
taking modulo 2). If the least significant bits are the same
(e.g., scan line number 242 and 356 both have a 0 least
significant bit and modulo 2), then the edges are in the same

25   field; otherwise, the edges are in different fields. Another
method is to count the number of intervening scan lines. If
the number of intervening scan lines is odd, then the edges are
in the same field; otherwise, the edges are in different
fields. Another method is to calculate the difference between

30   the numbered scan lines on which they reside. If the
difference is even, then the edges are in the same field;
otherwise, the edges are in different fields. If the edges are
in the same field, flicker will not be produced and the flicker
flag is not set at step 504.

35   If the horizontal edges are in different fields, the
system determines if the edges horizontally overlap at step
506. If the edges overlap, the system determines if the
overlap is greater than an overlap threshold at step 508. In

one embodiment, the overlap threshold is a user-defined variable. If the edges do not overlap or the overlap is not greater than the overlap threshold, flicker will not be produced and the flicker flag is not set at step 504.

If the horizontal edges overlap by more than the overlap threshold, the system determines if the vertical distance between the edges is less than a proximity threshold. In one embodiment, the proximity threshold is a user-defined variable. If the vertical distance between the edges is not less than the proximity threshold, flicker will not be produced and the flicker flag is not set at step 504.

If the vertical distance between the horizontal edges is less than the proximity threshold, the system determines if the differences in luminous intensity (or chroma-luminance in some embodiments) between the edges and the intervening background are the same sign and the absolute value of the differences are both greater than an intensity threshold. In one embodiment, the intensity threshold is a user-defined variable. The luminous intensity of each edge is compared to the luminous intensity of the intervening background to produce a difference. If the difference in luminous intensity between one of the edges and the background is not greater than the intensity threshold, flicker will not be produced and the flicker flag is not set at step 504. Flicker is caused by the transition of luminous intensity values on the interlaced display device.

At step 514, the flicker flag is set (i.e., on) as the horizontal edges will produce flicker when displayed. Although it is shown that a flag is set, it is not necessary that a flag be used at all. For example, in one embodiment, once the system has determined that the horizontal edge of the graphical object will produce flicker, the system just displays an edge in a different field. Constraining the edge in a different field will not produce flicker and will not unnecessarily reduce the resolution of the display. The edge may be displayed on the horizonal scan line above or below the scan line on which it was originally positioned.

For illustration purposes, the present invention is
described an analyzing horizontal edges of objects as they
interact with horizontal edges outside the object. However,
objects themselves are usually composed from lines, edges and
5   strips. The internal horizontal edges of graphical objects may
be similarly analyzed for flicker conditions as the internal
graphical elements of the object are created. For example,
when a horizontal strip is created, the two edges of the strip
may be analyzed to determine if they will interact with other
10   horizontal edges. Additionally, with horizontal strips, the
horizontal strip itself may separate two horizontal edges in
the background that interact to produce flicker as described
previously in reference to graphical object 304 in Fig. 6.
Testing for flicker conditions can be done interactively or as
15   a post design rule check depending on the application program.
In one embodiment, the system indicates to the user that a
horizontal edge of a graphical object being created will
produce flicker so the user may specify what action should be
taken. For example, a graphical drawing program or icon editor
20   may be creating an image that will be displayed on an
interlaced screen.

Once the system indicates flicker will be produced,
the user's choices may include displaying the edge in a
different field, changing the luminous intensity (or chroma-
25   luminance) of the edge, changing the shape, size or location of
the graphical object, and the like. Additionally, the user may
also specify to display the edge at the position that produces
flicker. In this manner, internal horizontal edges may be
checked for flicker when a graphical object is created.

30   Fig. 9 shows a flowchart of another embodiment of the
present invention that reduces flicker caused by graphical
objects. If the overlap, proximity, and intensity thresholds
are set strict enough, the above simplifies to the case where
all horizontal edges which are lighter than the adjacent
35   background will be in one selected field (e.g., odd field).
Conversely, all horizontal edges which are darker than the
adjacent background will be in the other field (e.g., even
field). Additionally, if all the horizontal edges of graphical

objects are darker (or light) than the background, flicker may
be reduced by constraining all horizontal edges of graphical
objects to be in the same field.

For simplicity, the following will describe
constraining all horizontal edges to the same field; however,
horizontal edges that are darker than the background may be
constrained to one field and horizontal edges that are lighter
than the background may be constrained to the other field by an
extension of these principles. At step 604, the system selects
a field on which all the horizontal edges of graphical objects
will be displayed.

The system determines if there are any horizontal
edges in the recently created or moved graphical object at step
604. In a preferred embodiment, the system not only checks for
horizontal edges in the graphical object but also compares the
length of the edges to a length threshold. If a horizontal
edge is not longer that the length threshold, the edge is not
processed any further. If there are no horizontal edges in the
graphical object, the graphical object will not produce flicker
and a flicker flag is not set at step 606.

If there are horizontal edges in the graphical
object, the system determines the position the graphical object
will be displayed on the screen at step 608. The system then
obtains a horizontal edge of the graphical object at step 610.
If, at step 614, the horizontal edge is in the field selected
to display horizontal edges, the edge will not produce flicker
and the flicker flag is not set at step 614. The system checks
if there is another horizontal edge of the graphical object to
process at step 616. If there is, the system gets the
horizontal edge at step 610 and processes the edge.

If the horizontal edge is not in the field selected
to display horizontal edges, the flicker flag is set at step
616. The flicker flag may be utilized as described above.
Therefore, the flicker flag may be used to indicate the flicker
condition to a user or application. Additionally, the system
may just display the horizontal edge in the field selected to
display horizontal edges either above or below its original
scan line.

Although the embodiment shown in Figs. 7 and 8 is
very flexible and retains more resolution, the embodiment shown
in Fig. 9 is very efficient and makes it easier for an
application program to check for a flicker condition.

5   Embodiments of the present invention may be made a part of an
application program, operating systems, software drivers, and
the like. For example, the operating system may have functions
for creating and moving graphical objects, including window
borders, without producing flicker on an interlaced display

10   device.

In a preferred embodiment, all the flicker conditions
are evaluated when an object is created. The internal
horizontal edges of an object are checked to see if they will
cause flicker. Also, all the outer horizontal edges are

15   constrained to be in the same field. When an object is
displayed or moved, the horizontal edges of the object are
checked to see if the edges will cause flicker because the
edges are in a different field than edges of a neighboring
object. Flicker is then avoided by moving the object where

20   possible. Thus, combinations of the methods of the present
invention may be utilized in the same system as follows.

Fig. 10 is a screen including a window having two
borders. A window 700 has a inner border 702 and an outer
border 704. For simplicity, the information at the center of

25   the window is not shown. Since horizontal edges that are in
the same field do not result in flicker, the window has been
created so that the inner and outer borders are in the same
field f_1. For example, the window may have been created using
the embodiment shown in Figs. 7 and 8 which could have been

30   used to also check the internal horizontal edges of the window
(not shown). Once the window has been created, the system may
insure that the window does not produce flicker by positioning
the window in the same field as other objects according the
embodiment shown in Fig. 9. This embodiment positions the

35   window in a selected field.

Still referring to Fig. 10, the system may constrain
the horizontal edges to be in a selected field in another
embodiment. Assume that the position of window 700 is

determined by the top left coordinates (x,y), where x specifies
the horizontal position and y specifies the vertical position.
If y indicates the binary value of the vertical position of the
object, the system can constrain the window to be in the
5   selected field (e.g., even) by forcing the least significant
bit to be always 0. This can be done by taking the y value and
performing an integer-divide-by-2 followed by multiply-by-2.
In assembly language this can also be accomplished by doing a
shift right followed by a shift left on the y or by doing a
10   logical AND with 0 to the least significant bit of y. Thus if
y=5, then y will be set to 4. In this manner the system
constrains the window to be in the selected field. To
constrain the window to be in the other field, the least
significant bit is always forced to a 1. This can be done by
15   adding 1 after the least significant bit has been forced to a 0
or doing a logical OR with 1 to the least significant bit of y.
This embodiment provides an efficient method for constraining
the horizontal edges of graphical window and other objects to
be in the selected field. Additionally, the system can insure
20   that the window is resized to have inner and outer borders that
are in the same field by constraining the height of the window
to be odd. The window's double borders are constrained to be
in the same field by constraining the border height to be also
odd. Once the object is created on the screen so that the
25   horizontal edges are in the selected field, y can be changed by
an even number of lines to keep the horizontal edges in the
selected field.

        This embodiment may also provide for graphic drawing
routines which will place horizontal edges in the selected
30   field. For instance a line draw function might define (x1,y1)
and (x2,y2) as two end points of a line. If y1=y2, the
function can force the least significant bit of both y1 and y2
to be either 0 or 1 to constrain the line to be placed on the
selected field. Similarly, a rectangle draw function, which
35   could be a filled rectangle or bordered rectangle, may define
(x1,y1) and (x2,y2) as the top-left and right-bottom corners of
a rectangle. The function can force the least significant bit
of both y1 and y2 to be either 0 or 1 to constrain the edges of

the rectangle to be in the selected field. Graphic drawing
programs and icon editors might use these functions to create
objects with horizontal edges, while other objects can be
created without the selected field restriction. The composite

5   object typically has a handle (x,y) which positions the object
on the screen. In order to place the horizontal edges of the
object on the selected field of the screen, the least
significant bit of y is set to either 0 or 1.

It should be readily apparent that the same analysis

10   would apply to a light border on a dark background and a dark
border on a light background. All the horizontal edges which
are lighter than the contiguous background will be in one
selected field (e.g., odd field). Conversely, all horizontal
edges which are darker than the adjacent background will be in

15   the other field (e.g., even field).

When horizontal edges are forced to be in a selected
field, horizontal strips that used to touch may have an
intervening scan line. However, if the height of one
horizontal strip is increased by one scan line so the

20   horizontal strips touch, that horizontal strip will consist of
an even number of scan lines which may produce flicker. In
order to reduce flicker, a higher priority is given to the
horizontal strip that differs from the background luminous
intensity by the greatest amount. The horizontal strip with

25   the lower priority is changed. For example, if a black
horizontal strip and gray horizontal strip originally touched
on a white background, the black horizontal strip will have
priority so the gray horizontal strip will be widened to touch
the black horizontal strip. Additionally, if two horizontal

30   strips are placed on the same scan line, a higher priority is
given to the horizontal strip that differs from the background
luminous intensity by the greatest amount.

If a border enclosed object is created (e.g., using a
draw bordered rectangle function) which has horizontal edges on

35   the selected field, then the enclosed area can be filled with
colors having a magnitude of difference in chroma-luminance
from the background less than that of the border. These rules
for overlapping strips and area fill in conjunction with the

line draw and rectangle draw functions forms a very useful tool
for creating objects which do not cause flicker and can be a
part of a graphic drawing program or an icon editor. This
embodiment may be combined with other methods. For example, a
5   window's borders and icons may be created and moved using an
embodiment of the present invention, but inside the window an
application might be running which does not use these rules,
(e.g., a text editor).

        The present invention may also provide an additional
10   check for dynamic pictures. Horizontal edges that are moving
on the screen generally do not produce flicker. Therefore, the
system allows moving horizontal edges to occupy any field so
that the edge moves smoothly (not jerky) because it is not
constrained to move two scan lines at a time to reduce flicker.

15   While the above is a complete description of the
preferred embodiments of the invention, various alternatives,
modifications and equivalents may be used. It should be
evident that the present invention is equally applicable by
making appropriate modifications to the embodiments described
20   above. For example, although software source and assembly code
that implements the present invention is included in a
Microfiche Appendix, the present invention may also be
implemented in hardware. Therefore, the above description
should not be taken as limiting the scope of the invention
25   which is defined by the metes and bounds of the appended
claims.

WHAT IS CLAIMED IS:

1	1. In a computer system, a method of reducing
2	flicker on an interlaced display device, comprising the steps
3	of:
4	providing a graphical object to be displayed at a
5	position on the interlaced display device;
6	identifying a first horizontal edge of the graphical
7	object, the first horizontal edge positioned in a first field
8	of the interlaced display device;
9	determining if the first horizontal edge of the
10	graphical object will substantially contribute to flicker on
11	the interlaced display device; and
12	displaying the first horizontal edge of the graphical
13	object in a second field of the interlaced display device to
14	reduce flicker on the interlaced display device.

1	2. The method of claim 1, wherein the first field
2	is an even or odd field of the interlaced display device.

1	3. The method of claim 1, wherein the identifying
2	step comprises the steps of:
3	comparing a length of the first horizontal edge of
4	the graphical object to a length threshold; and
5	processing the first horizontal edge of the graphical
6	object if the length is greater than the length threshold.

1	4. The method of claim 1, further comprising the
2	step of identifying a second horizontal edge.

1	5. The method of claim 4, wherein the graphical
2	object includes the second horizontal edge.

1	6. The method of claim 4, wherein another graphical
2	object or background includes the second horizontal edge.

1	7. The method of claim 4, wherein the determining
2	step comprises the steps of:

3   testing whether the first and second horizontal edges
4 are positioned in a same field of the interlaced display
5 .device; and
6   determining the first horizontal edge of the
7 graphical object will not substantially contribute to flicker
8 on the interlaced display device if the first and second
9 horizontal edges are positioned in the same field.

1   8.   The method of claim 4, wherein the testing step
2 comprises the steps of:
3   taking the modulo 2 of scan line numbers of the first
4 and second horizontal edges; and
5   determining the first and second horizontal edges are
6 in the same field of the interlaced display device if the
7 modulo 2 of their scan line numbers are the same.

1   9.   The method of claim 4, wherein the determining
2 step comprises the steps of:
3   comparing a horizontal overlap of the first and
4 second horizontal edges to an overlap threshold; and
5   determining the first horizontal edge of the
6 graphical object will not substantially contribute to flicker
7 on the interlaced display device if the horizontal overlap is
8 less than the overlap threshold.

1   10.   The method of claim 4, wherein the determining
2 step comprises the steps of:
3   comparing a vertical distance between the first and
4 second horizontal edges to a proximity threshold; and
5   determining the first horizontal edge of the
6 graphical object will not substantially contribute to flicker
7 on the interlaced display device if the vertical distance is
8 greater than the proximity threshold.

1   11.   The method of claim 4, wherein the determining
2 step comprises the steps of:
3   taking a difference in luminous intensity between the
4 first horizontal edge and an intermediate luminous intensity;

5   taking a difference in luminous intensity between the
6   second horizontal edge and the intermediate luminous intensity;
7   and
8   determining the first horizontal edge of the
9   graphical object will not substantially contribute to flicker
10 on the interlaced display device if signs of the differences
11 are different.

1   12. The method of claim 11, further comprising the
2   step of determining the first horizontal edge of the graphical
3   object will not substantially contribute to flicker on the
4   interlaced display device if the difference in luminous
5   intensity for either the first or second horizontal edge is not
6   greater than an intensity threshold.

1   13. The method of claim 11, wherein luminous
2   intensity is chroma-luminance.

1   14. The method of claim 1, wherein the first
2   horizontal edge is a horizontal edge of the graphical object
3   and the method further comprises the step of selecting the
4   second field to display horizontal edges of graphical objects
5   displayed on the interlaced display device.

1   15. The method of claim 14, wherein the determining
2   step comprises the steps of:
3   testing whether the first horizontal edge of the
4   graphical object is positioned in the first field of the
5   interlaced display device; and
6   determining the first horizontal edge of the
7   graphical object will substantially contribute to flicker on
8   the interlaced display device if the first horizontal edge of
9   the graphical object is positioned in the first field.

1   16. The method of claim 1, further comprising the
2   step of setting a flag to indicate that the first horizontal
3   edge of the graphical object will substantially contribute to
4   flicker on the interlaced display device.

1   17.   The method of claim 1, wherein the interlaced
2   display device is a television or interlaced computer monitor.

1   18.   In a computer system, a method of reducing
2   flicker on an interlaced display device, comprising the steps
3   of:
4   providing a graphical object to be displayed at a
5   position on the interlaced display device;
6   identifying a first horizontal edge of the graphical
7   object, the first horizontal line positioned in a first field
8   of the interlaced display device;
9   identifying a second horizontal edge positioned in a
10   second field of the interlaced display device;
11   comparing the first and second horizontal edges to
12   the determine if the first horizontal edge of the graphical
13   object will substantially contribute to flicker on the
14   interlaced display device; and
15   displaying the first horizontal edge of the graphical
16   object in the second field of the interlaced display device to
17   reduce flicker on the interlaced display device.

1   19.   The method of claim 18, wherein the graphical
2   object includes the second horizontal edge.

1   20.   The method of claim 18, wherein another
2   graphical object or background includes the second horizontal
3   edge.

1   21.   The method of claim 18, wherein the step of
2   identifying the second horizontal edge comprises the steps of:
3   taking the modulo 2 of scan line numbers of the first
4   and second horizontal edges; and
5   determining the second horizontal edge is in the
6   second field of the interlaced display device if the modulo 2
7   of their scan line numbers are different.

1   22.   The method of claim 18, wherein an identifying
2   step comprises the steps of:

3   comparing a length of a selected horizontal edge to a
4   length threshold; and
5   identifying the selected horizontal edge for further
6   processing if the length is greater than the length threshold.

1   23. The method of claim 18, wherein the comparing
2   step comprises the steps of:
3   comparing a horizontal overlap of the first and
4   second horizontal edges to an overlap threshold; and
5   determining the first horizontal edge of the first
6   graphical object will substantially contribute to flicker on
7   the interlaced display device if the horizontal overlap is
8   greater than the overlap threshold.

1   24. The method of claim 18, wherein the comparing
2   step comprises the steps of:
3   comparing a vertical distance between the first and
4   second horizontal edges to a proximity threshold; and
5   determining the first horizontal edge of the
6   graphical object will substantially contribute to flicker on
7   the interlaced display device if the vertical distance is less
8   than the proximity threshold.

1   25. The method of claim 18, wherein the comparing
2   step comprises the steps of:
3   taking a difference in luminous intensity between the
4   first horizontal edge and an intermediate luminous intensity;
5   taking a difference in luminous intensity between the
6   second horizontal edge and the intermediate luminous intensity;
7   and
8   determining the first horizontal edge of the
9   graphical object will not substantially contribute to flicker
10   on the interlaced display device if signs of the differences
11   are different.

1   26. The method of claim 25, further comprising the
2   step of determining the first horizontal edge of the graphical
3   object will not substantially contribute to flicker on the

4   interlaced display device if the difference in luminous

5   intensity for either the first or second horizontal edge is not

6   greater than an intensity threshold.

1   27. In a computer system, a method of reducing

2   flicker on an interlaced display device, comprising the steps

3   of:

4   providing a first graphical object to be displayed at

5   a position on the interlaced display device;

6   identifying a horizontal edge of the first graphical

7   object, the horizontal edge of the first graphical object

8   positioned in a first field of the interlaced display device;

9   identifying a horizontal edge of a second graphical

10   object, the horizontal edge of the second graphical object

11   positioned in a second field of the interlaced display device;

12   comparing a horizontal overlap of the horizontal

13   edges of the first and second graphical objects to an overlap

14   threshold;

15   comparing a distance between the horizontal edges of

16   the first and second graphical objects to a proximity

17   threshold;

18   taking a difference in luminous intensity between the

19   horizontal edge of the first graphical object and an

20   intermediate luminous intensity;

21   taking a difference in luminous intensity between the

22   horizontal edge of the second graphical object and the

23   intermediate luminous intensity;

24   determining the horizontal edge of the first

25   graphical object will substantially contribute to flicker on

26   the interlaced display device if the horizontal overlap is

27   greater than the overlap threshold and the vertical distance is

28   less than the proximity threshold and signs of the differences

29   in luminous intensity are the same; and

30   displaying the horizontal edge of the first graphical

31   object in the second field of the interlaced display device if

32   it is determined that the horizontal edge of the first

33   graphical object will substantially contribute to flicker on

34   the interlaced display device.

1   28.   The method of claim 27, further comprising the
2   step of determining the first horizontal edge of the graphical
3   object will not substantially contribute to flicker on the
4   interlaced display device if the difference in luminous
5   intensity for either the first or second horizontal edge is not
6   greater than an intensity threshold.

1   29.   The method of claim 27, wherein the step of
2   identifying the second horizontal edge comprises the steps of:
3   taking the modulo 2 of scan line numbers of the first
4   and second horizontal edges; and
5   determining the second horizontal edge is in the
6   second field of the interlaced display device if the modulo 2
7   of their scan line numbers are different.

1   30.   The method of claim 27, wherein an identifying
2   step comprises the steps of:
3   comparing a length of a selected horizontal edge of a
4   graphical object to a length threshold; and
5   identifying the selected horizontal edge for further
6   processing if the length is greater than the length threshold.

1   31.   In a computer system, a method of reducing
2   flicker on an interlaced display device, comprising the steps
3   of:
4   selecting a field of the interlaced display device to
5   display selected horizontal edges of graphical objects
6   displayed on the interlaced display device;
7   providing a graphical object to be displayed on the
8   interlaced display device; and
9   constraining the selected horizontal edges of the
10 graphical object to the selected field on the interlaced
11 display device.

1   32.   The method of claim 31, further comprising the
2   step of selecting a horizontal edge of the graphical object if
3   the horizontal edge is darker than a background luminous
4   intensity.

1   33.   The method of claim 32, further comprising the
2   step of constraining horizontal edges of the graphical object
3   that are lighter than the background luminous intensity to the
4   other field of the interlaced display device.

1   34.   The method of claim 31, wherein the constraining
2   step includes an integer-divide-by-2 step and a multiply-by-2
3   step.

1   35.   A computer system, comprising:
2   a computer having a memory;
3   an interlaced display device coupled to the computer;
4   at least one flicker condition for the interlaced
5   display device stored in the memory; and
6   a program stored in the memory that determines if a
7   horizontal edge of a graphical object will substantially
8   contribute to flicker upon reference to the at least one
9   flicker condition, the program directing the interlaced display
10   device to display the horizontal edge on a different field if
11   the horizontal edge will substantially contribute to flicker.

1   36.   A computer system, comprising:
2   means for providing a graphical object to be
3   displayed at a position on the graphical image;
4   means for identifying a horizontal edge of the
5   graphical object, the horizontal edge positioned in a first
6   field of the interlaced display device when displayed;
7   means for determining if the horizontal edge of the
8   graphical object will substantially contribute to flicker on
9   the interlaced display device; and
10   means for displaying the horizontal edge of the
11   graphical object in a second field of the interlaced display
12   device to reduce flicker on the interlaced display device.

1   37.   A computer program product that reduces flicker
2   on an interlaced display device, comprising:
3   computer code that identifies a horizontal edge of a
4   graphical object to be displayed on the interlaced display

5   device, the horizontal edge positioned in a first field of the
6   interlaced display device when displayed;
7   computer code that determines if the horizontal edge
8   of the graphical object will substantially contribute to
9   flicker on the interlaced display device;
10   computer code that displays the horizontal edge of
11 the graphical object in a second field of the interlaced
12 display device to reduce flicker on the interlaced display
13 device; and
14   a computer readable storage medium that stores the
15 computer codes.

1   38. A computer system, comprising:
2   a computer having a memory;
3   an interlaced display device coupled to the computer;
4   and
5   a program stored in the memory that determines
6   constrains selected horizontal edges of a graphical object to
7   the same field on the interlaced display device in order to
8   reduce flicker.

1   39. A computer system, comprising:
2   means for selecting a field of the interlaced display
3   device to display selected horizontal edges of graphical
4   objects displayed on the interlaced display device;
5   means for providing a graphical object to be
6   displayed on the interlaced display device; and
7   means for constraining the selected horizontal edges
8   of the graphical object to the selected field on the interlaced
9   display device.

1   40. A computer program product that reduces flicker
2   on an interlaced display device, comprising:
3   computer code that selects a field of the interlaced
4   display device to display selected horizontal edges of
5   graphical objects displayed on the interlaced display device;
6   computer code that provides a graphical object to be
7   displayed on the interlaced display device;

8   computer code that constrains the selected horizontal

9   edges of the graphical object to the selected field on the

10   interlaced display device; and

11   a computer readable storage medium that stores the
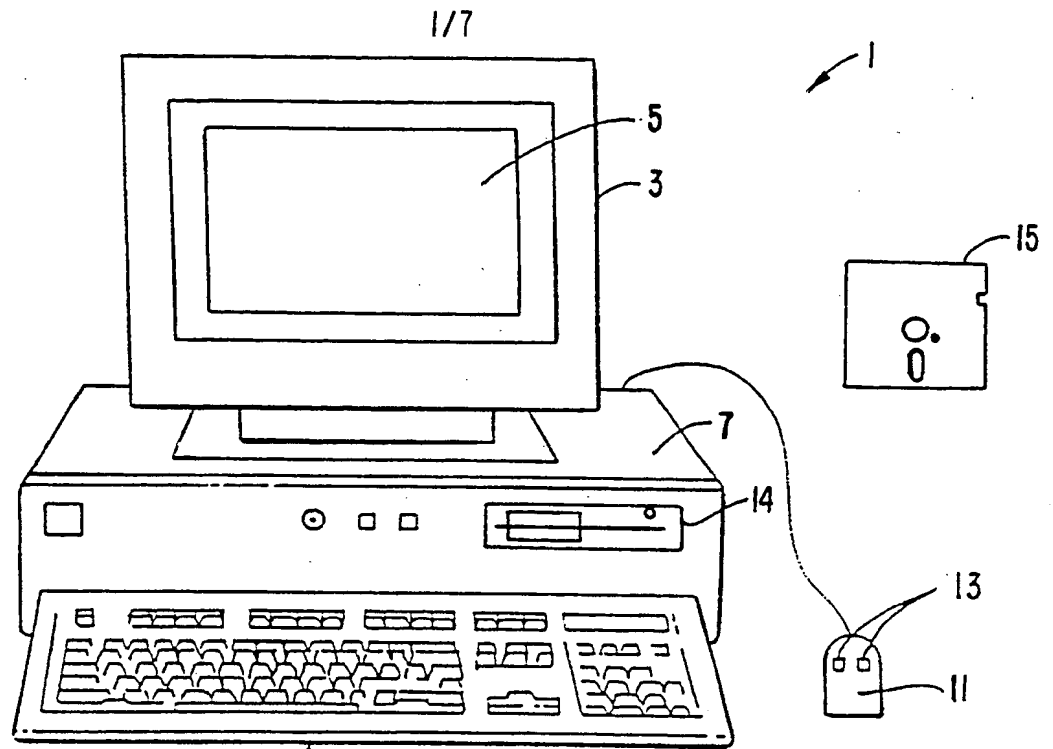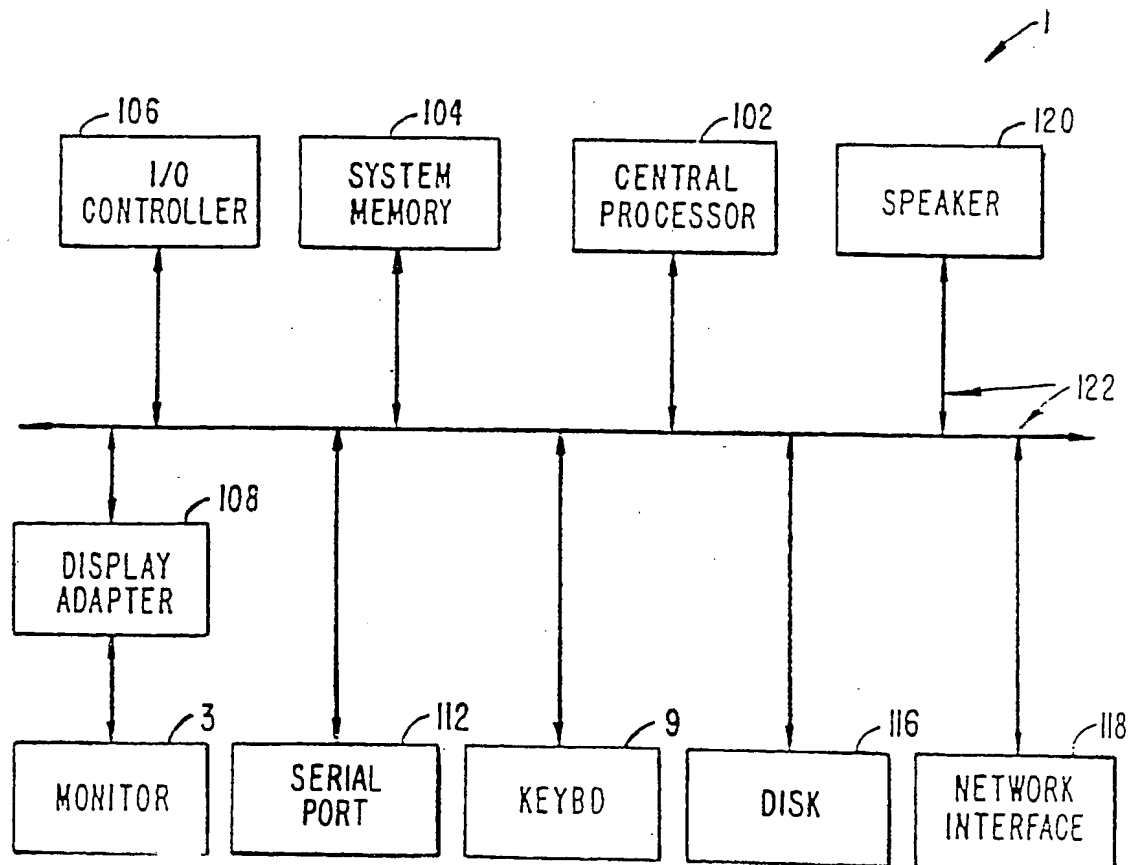
12   computer codes.

1/7

FIG. 1.
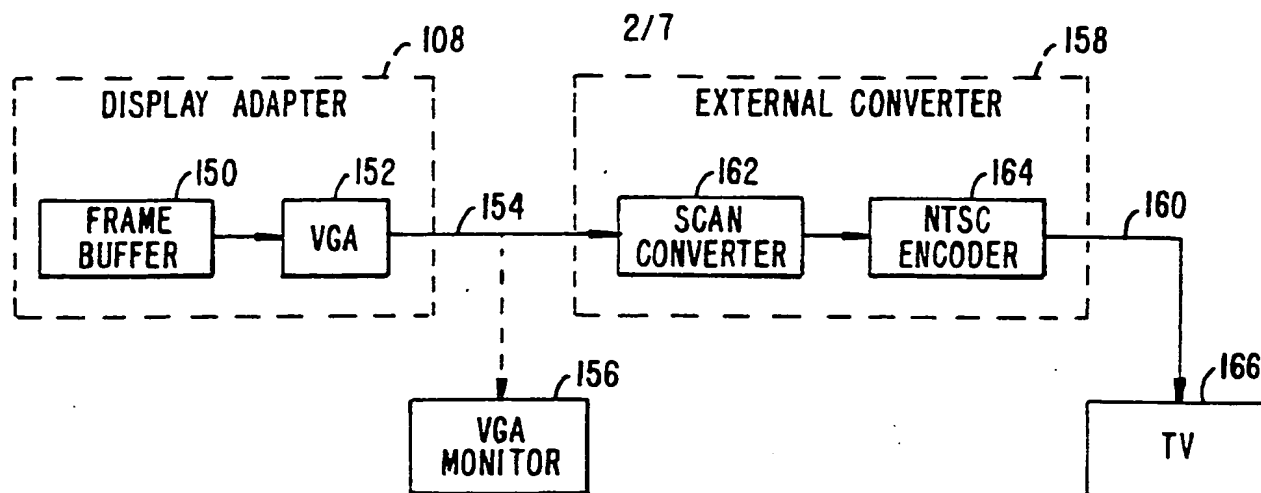

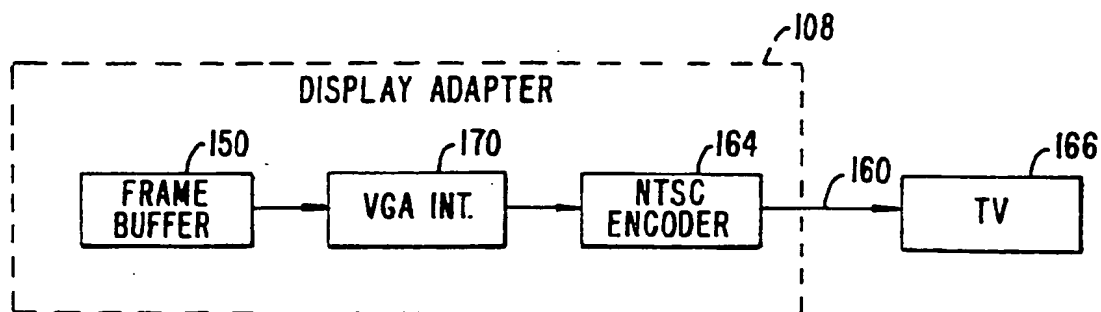*FIG. 2.*

SUBSTITUTE SHEET (RULE 26)

DISPLAY ADAPTER ~108

FRAME BUFFER ~150 → VGA ~152 → ~154

VGA MONITOR ~156

EXTERNAL CONVERTER ~158

SCAN CONVERTER ~162 → NTSC ENCODER ~164 → ~160

TV ~166

FIG. 3A.

DISPLAY ADAPTER ~108

FRAME BUFFER ~150 → VGA INT. ~170 → NTSC ENCODER ~164 → ~160 → TV ~166

FIG. 3B.

5

202

206 210

212

208

204
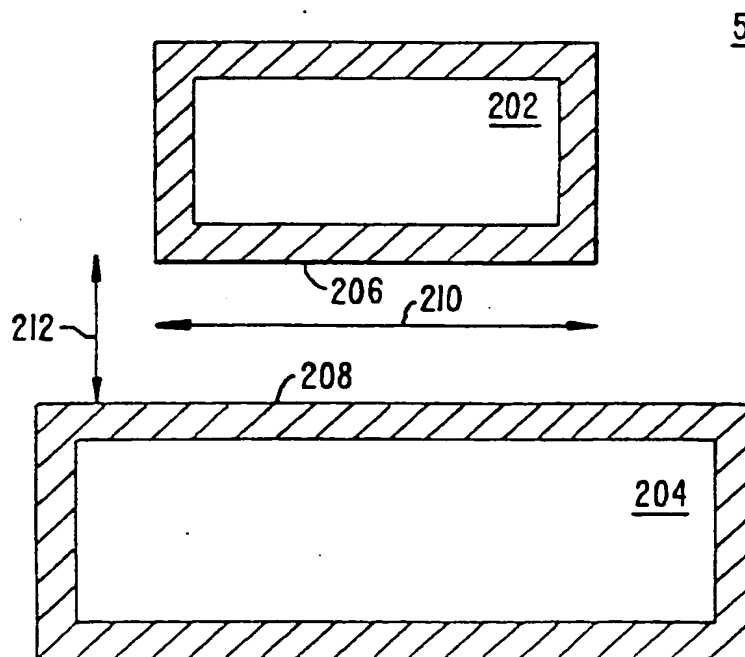
FIG. 4.
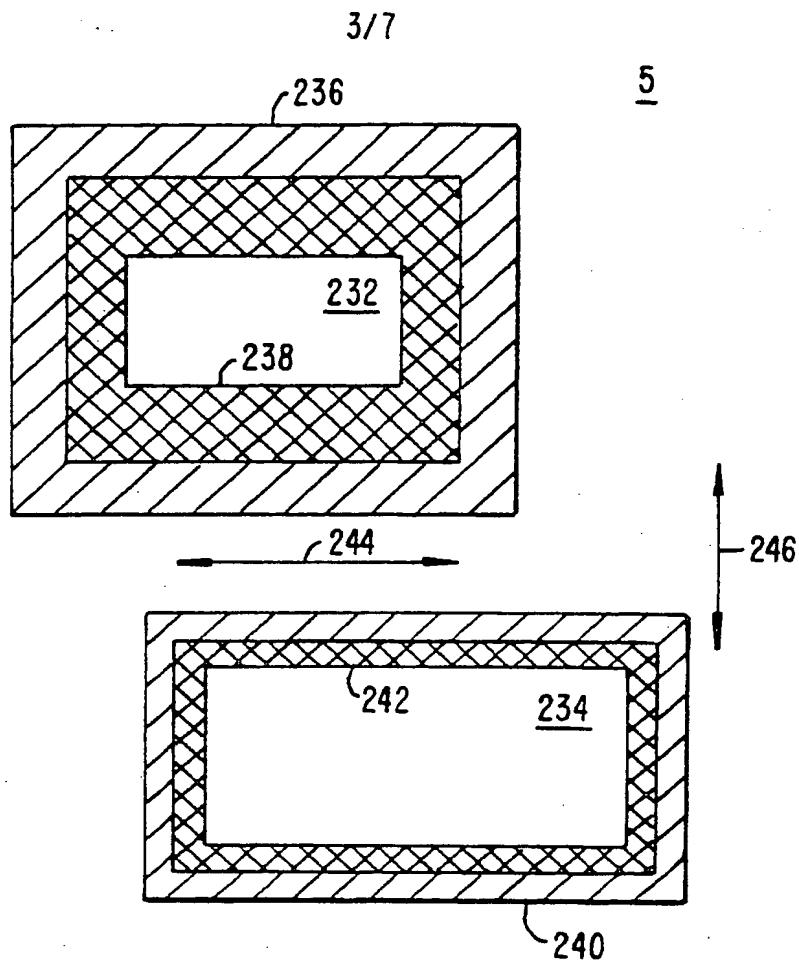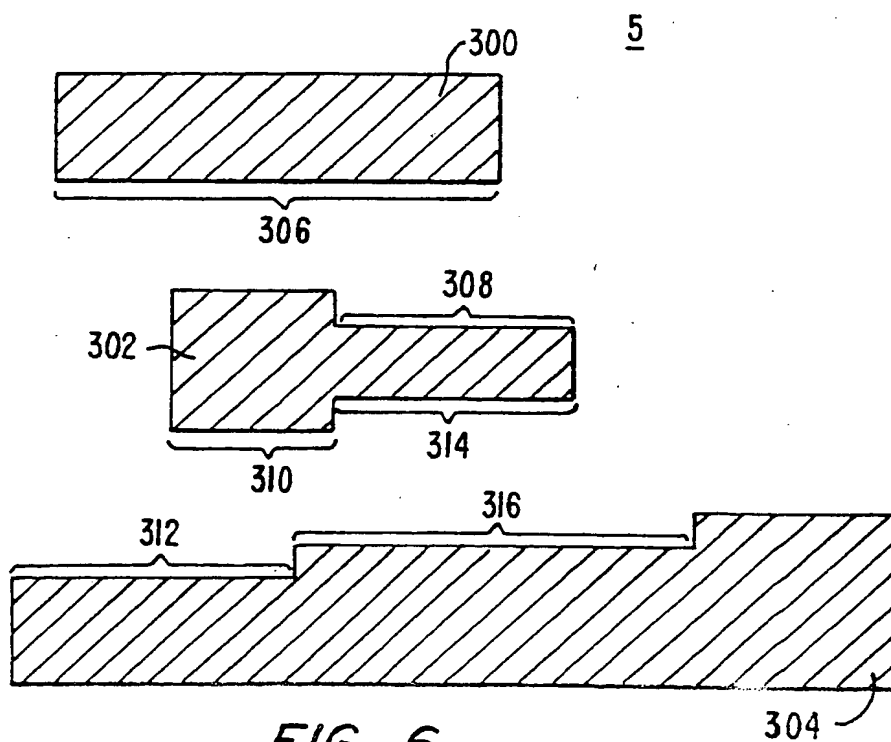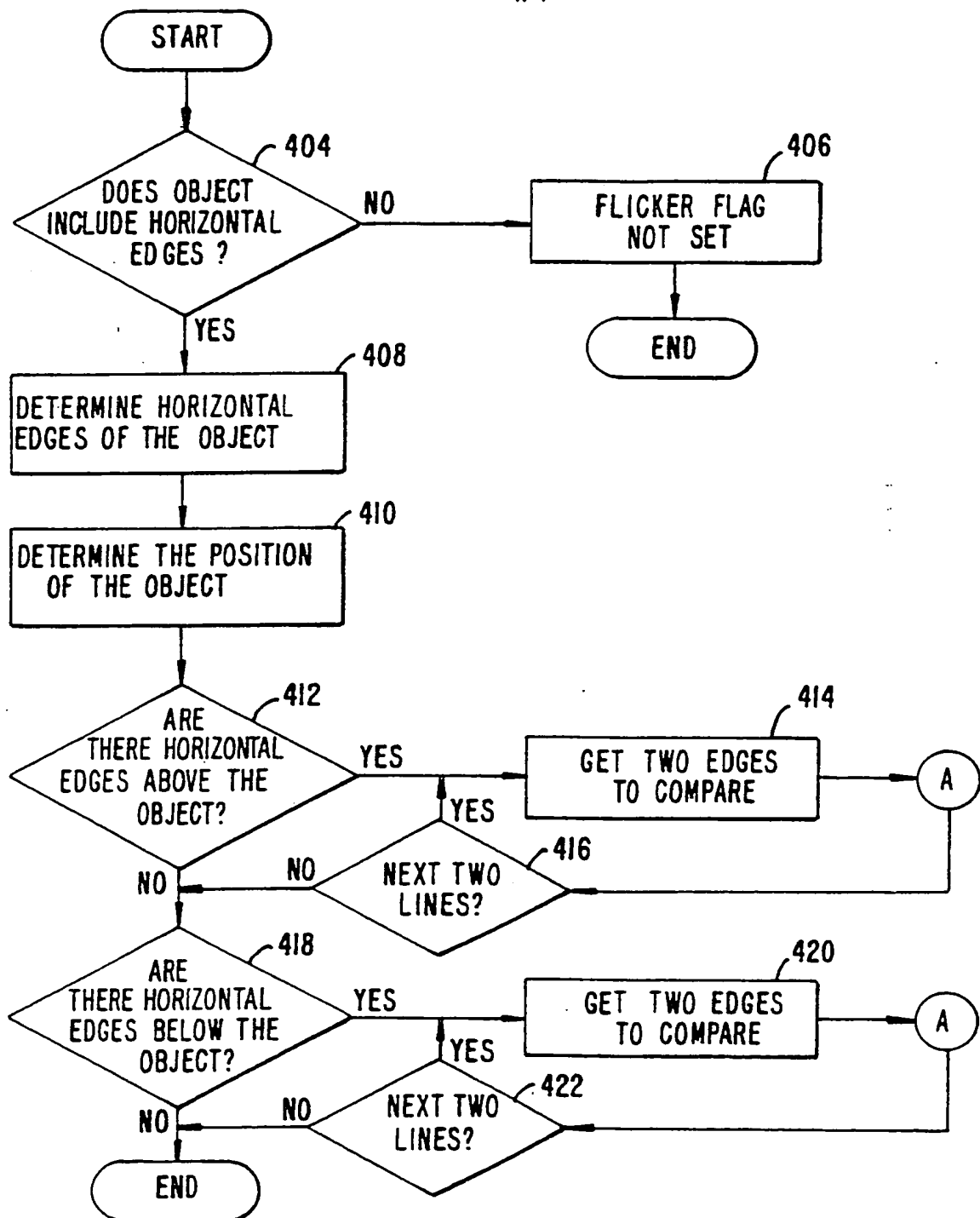
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236

232

238

244   246

242   234

240

FIG. 5.

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300

306

308

302

314

310

312   316

FIG. 6.

304

FIG. 7.
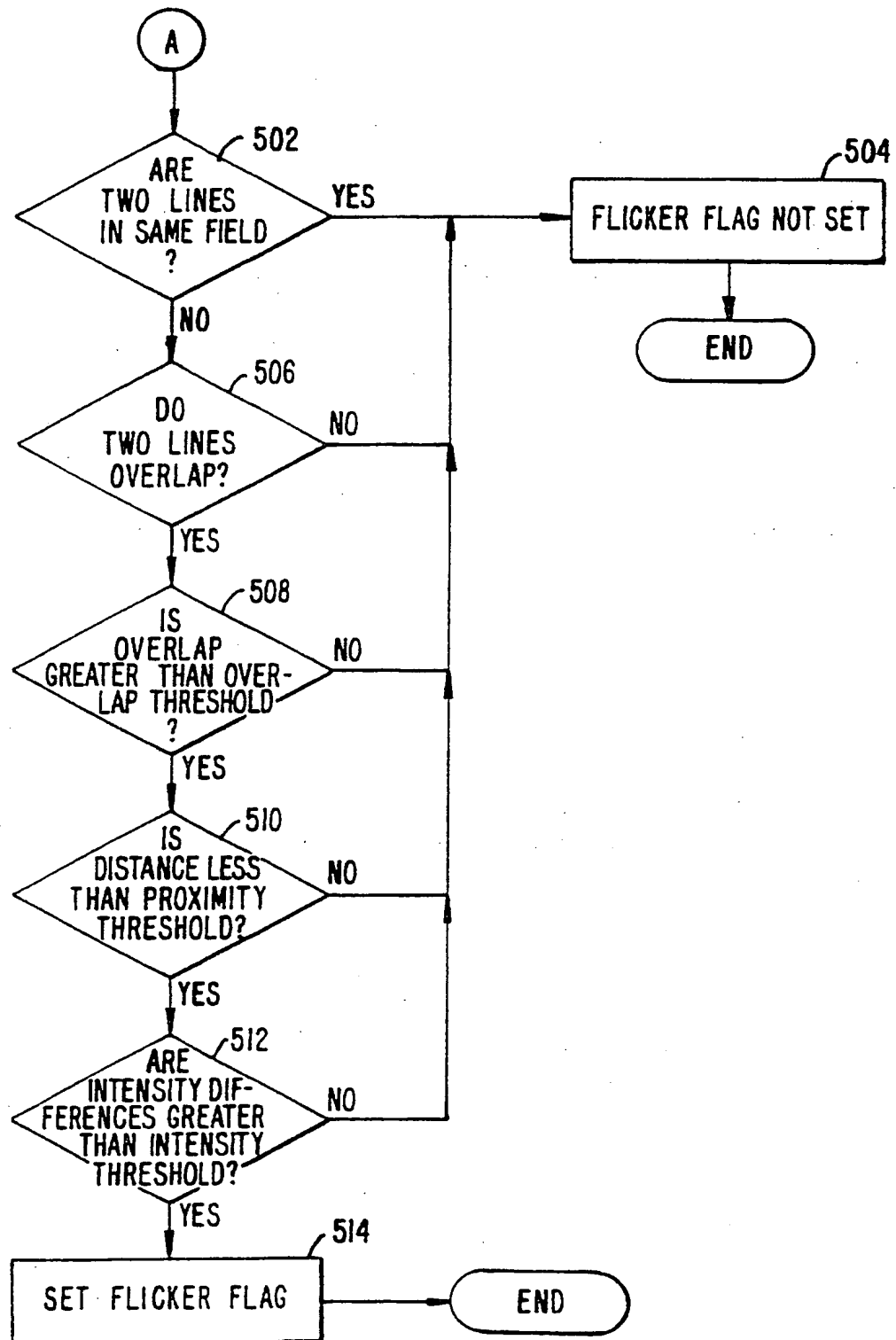
FIG. 8.
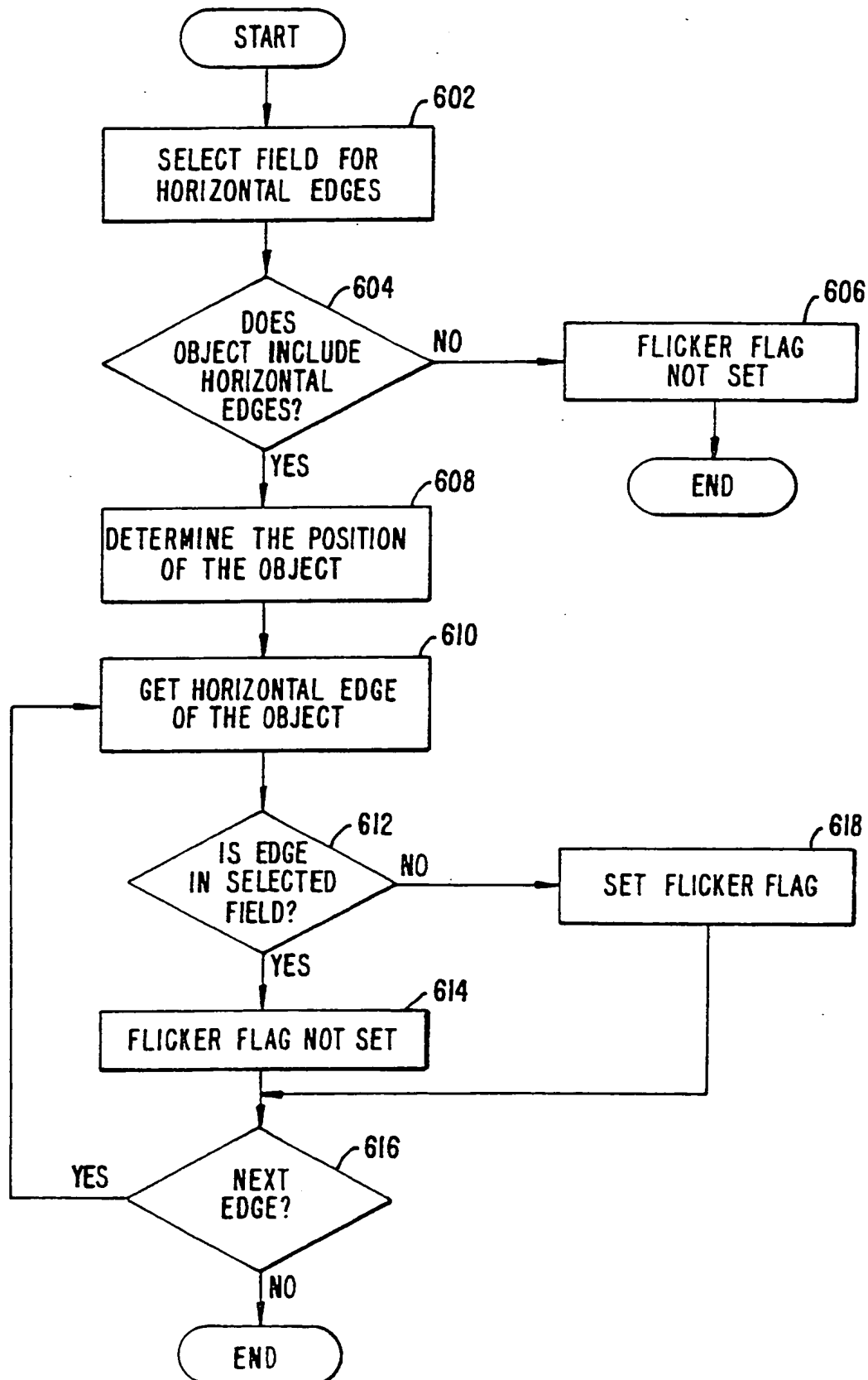
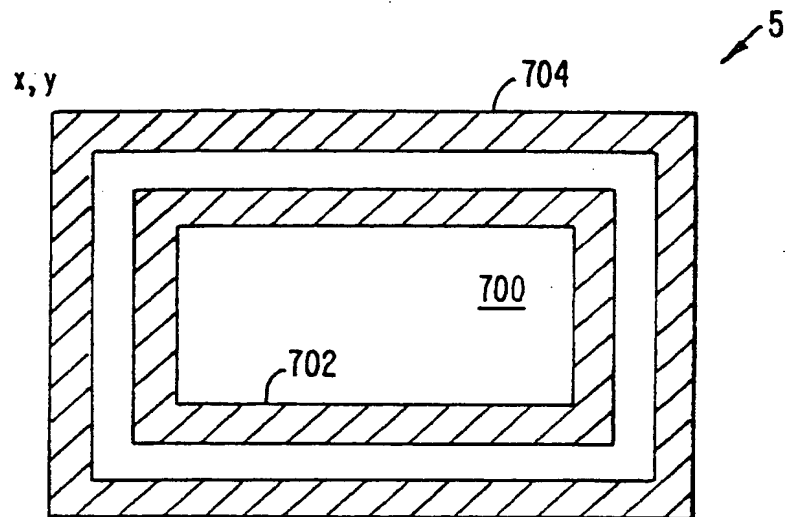*FIG. 9.*

FIG. 10.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/12350

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G09G 5/36

US CL :345/136

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

  U.S. : 345/136-138, 118-121, 113-114, 133, 152, 212-213, 209; 348/526, 528-529

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

  NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

  NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,763,120 (MORRISH ET AL.) 09 August 1988, abstract, col. 4, lines 43-65.	1-40

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
		"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 OCTOBER 1996	16 OCT 1996

Name and mailing address of the ISA/US	Authorized officer
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